UNIVERSITY OF CALIFORNIA PUBLICATIONS

COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BERKELEY, CALIFORNIA

FEEDING DAIRY CALVES IN CALIFORNIA

BY

F. W. WOLL AND E. C. VOORHIES

BULLETIN No. 271

September, 1916

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY
1916

Benjamin Ide Wheeler, President of the University.

EXPERIMENT STATION STAFF

HEADS OF DIVISIONS

Thomas Forsyth Hunt, Director.
Edward J. Wickson, Horticulture (Emeritus).
Herbert J. Webber, Director Citrus Experiment Station; Plant Breeding.
Hubert E. Van Norman, Vice-Director; Dairy Management.
William A. Setchell, Botany.
Myer E. Jaffa, Nutrition.
Robert H. Loughridge, Soil Chemistry and Physics (Emeritus).
Charles W. Woodworth, Entomology.
Ralph E. Smith, Plant Pathology.
J. Eliot Coit, Citriculture.
John W. Gilmore, Agronomy.
Charles F. Shaw, Soil Technology.
John W. Gregg, Landscape Gardening and Floriculture.
Frederic T. Bioletti, Viticulture and Enology.
Warren T. Clarke, Agricultural Extension.
John S. Burd, Agricultural Chemistry.
Charles B. Lipman, Soil Chemistry and Bacteriology.
Clarence M. Haring, Veterinary Science and Bacteriology.
Ernest B. Babcock, Genetics.
Gordon H. True, Animal Husbandry.
James T. Barrett, Plant Pathology.
Fritz W. Woll, Animal Nutrition.
A. V. Stubenrauch, Pomology.
Walter Mulford, Forestry.
W. P. Kelley, Agricultural Chemistry.
H. J. Quayle, Entomology.
Elwood Mead, Rural Institutions.
J. B. Davidson, Agricultural Engineering.
H. S. Reed, Plant Physiology.
D. T. Mason, Forestry.
William G. Hummel, Agricultural Education.
John E. Dougherty, Poultry Husbandry.
S. S. Rogers, Olericulture.
*Frank Adams, Irrigation Investigations.
David N. Morgan, Assistant to the Director.
Mrs. D. L. Bunnell, Librarian.

Division of Animal Husbandry

Gordon H. True
F. W. Woll
J. I. Thompson
R. F. Miller
E. C. Voorhies
Miss C. J. Hill

* In co-operation with office of Public Roads and Rural Engineering, U. S. Department of Agriculture.

FEEDING DAIRY CALVES IN CALIFORNIA

By F. W. WOLL and E. C. VOORHIES

The subject of calf raising is one of fundamental importance to the dairy farmer, and success or failure in raising the calf crop depends at least as much on the method of feeding adopted, as on the care and handling which the young stock receives. With the increase in city population, a larger proportion of the milk produced on dairy farms is used every year for direct consumption, or for the manufacture of condensed milk or cheese; and the supply of skim milk for feeding young stock is reduced in proportion. This renders it more difficult for the dairy farmer to raise healthy vigorous calves that will develop into good dairy cows, and makes it especially important to utilize the skim milk at the disposal of the farmer in such a manner as to secure the best results with it in raising his young stock.

There is but little definite information as to the value of the various dairy feeds that are available in this state for calf feeding; nearly all experiments with calves on record having been conducted with feeding stuffs different from those commonly used here, or under conditions that vary greatly from those existing here. In order to supply some accurate information on different calf-feeding problems in this state, and to ascertain in how far calves can be profitably raised on skim milk with supplementary feeds under our conditions, the Division of Animal Husbandry has for nearly two years past conducted a series of investigations on the value of different grain mixtures for feeding calves. The present bulletin presents brief accounts of these trials, and such general information relating to the subject of raising calves as experience has taught us will be useful to our dairy farmers.

METHOD OF RAISING SKIM MILK CALVES

The general method of raising calves in the University dairy herd and among good dairy farmers in the state is about as follows: The new-born calf is, as a rule, left with the dam for a day only; if the udder is greatly inflamed or the calf is very weak it is kept with the cow for several days. It is fed whole milk for about two weeks; at first three times a day, later twice a day, and is then gradually changed to skim milk in the course of a week or ten days. Fresh

warm skim milk is fed from this time on until weaning time, at four to five months of age. The time of changing from whole milk to skim milk varies according to the vigor and the value of the calves. It is aimed to bring them on to skim milk soon after two weeks, unless some special reason renders it desirable to continue the feeding of whole milk for a longer period. It has been abundantly proved, both by direct experiments and by the experience of practical dairy farmers, that as thrifty and vigorous calves can be raised on skim milk with proper supplementary grain feeds as on whole milk, and the expense of raising the calves will be reduced to nearly one-fourth by this method of feeding. Direct experiments have shown that the feeding value of whole milk and skim milk for young stock stands in a ratio of about 2 to 1, while the common wholesale or creamery prices of the two products are about 8 to 1.

At the time the calf is put on skim milk diet, it receives a small amount of a grain mixture that is gradually increased from less than one-quarter of a pound daily to about two pounds at weaning time. Bright, fine alfalfa hay or grain hay is also kept before the calves during this period, as well as clean drinking water and salt. The grain mixture for the calves is changed from time to time, according to the special feeds at hand. It is generally composed of standard dairy feeds only, like barley, oats, wheat middlings, dried beet pulp, linseed meal, etc.

CALF-FEEDING TRIALS AT THE UNIVERSITY FARM

The following statement will show the calf-feeding trials conducted during the past two years at the University Farm and reported in this bulletin, with character of grain mixtures fed, length of trials, etc. It will be noted that the following problems have been studied in these trials: The value of linseed meal in various grain mixtures for skim-milk calves; carob pods vs. barley, and dried beet pulp vs cocoanut meal as components of grain mixtures for such calves.

Trial No.	No. of calves included on trial	Grain mixtures fed	Length of trials
I	16	Barley, oats, wheat middlings, with or without linseed meal	Nov. 19, '14–Jan. 28, '15
II	24	Milo and barley, with or without linseed meal	Feb. 4–April 22, '15
III	5	Barley, shorts, linseed meal	May 27–Sept. 16, '15
IV	14	Carob pods and milo vs. barley and milo	Oct. 21, '15–Jan. 20, '16
V	16	Dried beet pulp and barley vs. cocoanut meal and barley	Jan. 27–April 6, '16

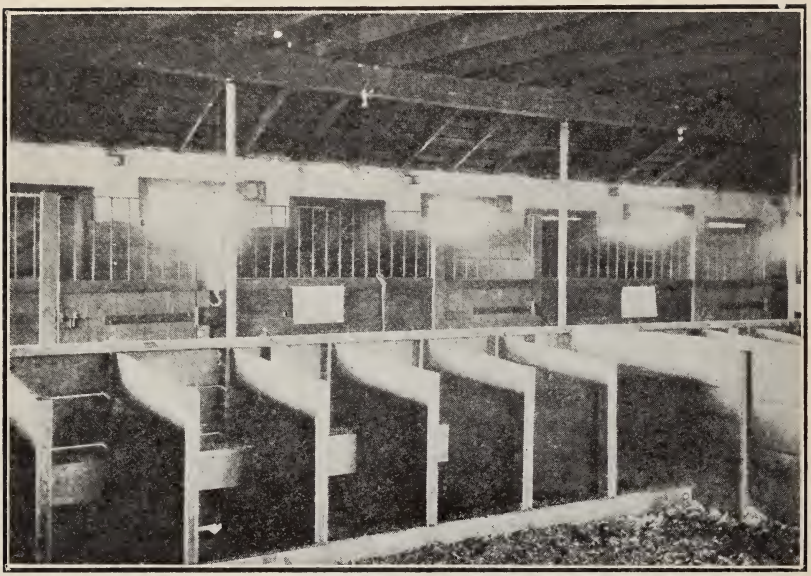

Fig. 1.—Interior of calf barn, rear view of stalls.

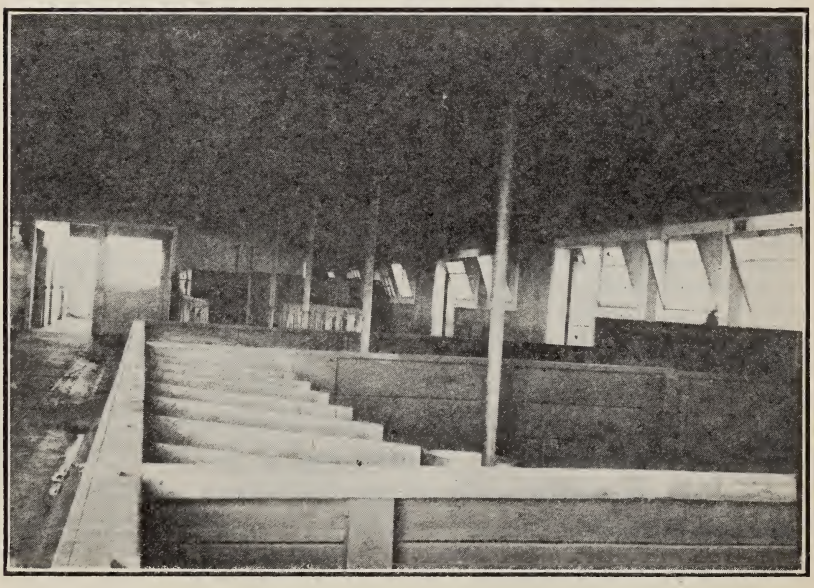

Fig. 2.—Interior of calf barn, side view of stalls.

The main facts relating to these trials are briefly stated in the following pages, with important results obtained and discussions of the same.

ANALYSES OF FEEDING STUFFS

Samples of the feeds used in the trials reported in this bulletin, except of the skim milk and whole milk, were forwarded at regular intervals to the Nutrition Laboratories at Berkeley for chemical analysis. The kind co-operation of Professor M. E. Jaffa, Chief of the laboratories, in making the chemical analyses and thus aiding in determining the feed components actually consumed by the calves, is gratefully acknowledged. The results of the chemical analyses of the feeding stuffs fed in this and following calf feeding trials are given in Table I, which will also show the digestible components of the various feeds, calculated on the basis of the best available digestion coefficients for the feeds.

PRICES OF FEEDS

The prices at which the various feeds used in the different trials are calculated are given in the following table; they are in most cases average San Francisco market quotations for the five years, 1911–1915, inclusive.

	Per ton	Cents
Barley (rolled or ground)	$29.50	1.5 per lb.
Oats (ground)	34.00	1.7
Wheat middlings	29.50	1.5
Linseed meal	38.50	1.9
Cocoanut meal	27.00	1.3
Dried beet pulp	24.00	1.2
Alfalfa hay	10.50	.5
Milo maize	.....	1.5
Carob pods	.....	1.5
Skim milk	.....	25.0 per cwt.
Whole milk	.....	16.0 per gal.

TRIAL I. Linseed Meal as a Component of Grain Mixtures for Skim-Milk Calves

Whole milk is the ideal feed for calves. It contains all the elements necessary for sustenance and growth, and in the right proportions to secure the best physiological effects. On account of its high value as a human food it can, however, be fed profitably to calves and other young stock, only for a short time, and these are, therefore, ordinarily brought over to a skim-milk diet after the first two or three weeks. The main difference between the two kinds of milk lies in their fat

COMPOSITION OF FEEDING STUFFS USED ON CALF-FEEDING EXPERIMENTS, 1914–16, IN PER CENT

Name of feed	Laboratory No.	Moisture	Protein	Fat	Fiber	N-free Extract	Ash	Digestible Components Protein	Digestible Components Carbohydrates and fat	Nutr. Ratio
Alfalfa hay	1188	23.00	17.50	2.70	19.55	29.25	8.00			
Alfalfa hay	1208	12.00	14.49	.91	30.86	33.84	7.90			
Alfalfa hay	1210	17.66	13.61	2.22	22.38	36.72	7.41			
Alfalfa hay	1215	15.87	11.32	1.30	28.63	35.85	7.03			
Alfalfa hay	1218	9.95	16.28	1.88	30.68	33.44	7.77			
Alfalfa hay	1295	25.36	13.49	2.73	19.18	33.71	5.53			
Alfalfa hay	1367	13.18	13.88	1.34	23.50	40.66	7.44			
Alfalfa hay	1368	16.43	9.54	1.46	28.81	38.39	5.37			
Alfalfa hay.	1370	16.24	14.88	1.12	18.98	42.35	6.43			
Alfalfa hay	1446	16.95	15.03	2.25	18.32	39.80	7.65			
Average (1914–15)		16.66	14.00	1.79	24.09	36.41	7.05	9.9	38.1	1:3.8
Alfalfa hay	1549	12.80	13.02	2.74	29.84	34.94	6.66			
Alfalfa hay	1552	13.81	12.12	2.01	29.81	35.37	6.88			
Average (1915–16)		13.31	12.57	2.37	29.82	35.16	6.77	8.9	40.2	1:4.5
Rolled barley	1217	12.36	10.37	1.80	6.26	66.61	2.60			
Rolled barley	1369	12.80	10.37	2.35	5.10	66.23	3.15			
Rolled barley	1405	10.38	10.33	2.66	6.76	66.87	3.00			
Rolled barley	1437	13.43	10.39	2.40	5.35	65.63	2.80			
Rolled barley	1484	11.96	8.49	2.35	5.80	68.76	2.64			
Rolled barley	1548	9.50	11.40	2.24	6.55	67.08	3.23			
Rolled barley	1741	13.44	10.33	3.29	5.45	65.11	2.38			
Average		11.98	10.24	2.44	5.90	66.61	2.83	8.0	68.9	1:8.6

COMPOSITION OF FEEDING STUFFS USED ON CALF-FEEDING EXPERIMENTS, 1914–16, IN PER CENT (*Cont'd*)

Name of feed	Laboratory No.	Moisture	Protein	Fat	Fiber	N-free Extract	Ash	Digestible Components Protein	Digestible Components Carbh & fat	Nutr. Ratio
Rolled oats	1212	15.39	6.62	3.11	7.42	63.65	3.81	5.2	60.3	1:11.6
Milo maize	1441	14.87	6.96	2.78	1.50	71.27	2.62			
Milo maize	1705	9.35	8.98	1.77	2.65	74.52	2.73			
Milo maize	1740	12.30	8.31	1.49	2.20	73.98	1.72			
Average		12.17	8.08	2.01	2.12	73.26	2.36	4.6	59.2	1:12.9
Wheat middlings	1302	8.75	16.35	4.20	3.40	65.15	2.15			
Wheat middlings	1381	11.09	14.67	3.75	5.52	61.03	3.94			
Wheat middlings	1440	12.16	12.34	3.82	3.30	65.23	3.15			
Average		10.67	14.45	3.92	4.07	63.81	3.08	11.1	58.8	1:5.3
Molasses beet pulp	1637	8.50	11.02	.56	10.52	62.27	7.13	6.8	65.1	1:9.6
Linseed oil meal	1300	8.00	34.80	8.50	8.20	34.90	5.60			
Linseed oil meal	1404	9.45	33.60	8.80	8.96	33.69	5.50			
Linseed oil meal	1438	10.05	39.54	8.38	6.03	29.96	6.04			
Linseed oil meal	1483	8.82	36.96	7.96	7.27	32.81	6.18			
Average		9.08	36.20	8.43	7.62	32.84	5.83	32.2	46.8	1:1.5
Cocoanut meal	1547	9.41	21.66	9.50	8.30	45.36	5.77	19.5	62.8	1:3.2
Carob pods	1704	11.91	7.96	1.00	5.60	71.86*	1.67	2.4	66.5	1:27.7
Skim milk ϕ		90.5	3.5	.2		4.9	.9	3.3	5.4	1:1.6
Whole milk ϕ		87.3	3.4	3.7		4.9	.7	3.2	13.2	1:4.1

ϕ Average analyses

* Total sugar 26.90 per cent (sucrose 13.96 per cent., dextrose 12.94 per cent).

content. Whole milk contains, on the average, 3.5 per cent butter fat, as against .1 per cent or .2 per cent for separator skim milk; the latter is, on the other hand, somewhat higher in protein and in ash, and is lower in milk sugar than is whole milk. As a result, the nutritive ratio (proportion of digestible protein to non-protein) of skim milk is considerably narrower that that of whole milk, viz., 1:1.6 as against 1:4.1. Since whole milk contains the essential feed components in the proportion best suited to the needs of young stock, it may be concluded that it will not be safe to vary greatly from this proportion in substituting other feeds for it, and that a nutritive ratio of about 1:4 will be likely to prove most effective in feeding this class of farm animals.

In changing from whole milk to skim milk for feeding young stock it is necessary to furnish some additional feed or feeds that will supply the deficiency of non-protein substances in the skim milk, viz., either fat, or feed materials of similar physiological effects, like starch or related substances. Feeds of this character available to California farmers are: cereal grains, especially Indian corn, barley and oats; sorghum varieties like milo, kafir, Egyptian corn, feterita; mill feeds like wheat bran and middlings, rice bran (if unadulterated), rice polish, and other factory by-products like dried plain or molasses beet pulp and cocoanut meal. Considering the average market prices for feeding stuffs in this state, Indian corn, oats, and mill feeds are, as a rule, too expensive in comparison with the other feeds named, to be included in grain mixtures for skim-milk calves.

Practical experience has shown that most satisfactory results may be secured in feeding calves by supplementing skim milk with low-protein grain feeds, and it will be noted from the foregoing, that this is based on good theoretical grounds, since the nutritive ratios of such skim-milk rations will approximate that of whole milk. However, mixtures containing medium-protein and even high-protein feeds, like linseed meal, are also frequently fed by dairy farmers. The regular grain mixtures fed to calves at many of the experiment stations and recommended by good authorities are composed of cereal grains with certain proportions of either wheat bran or middlings and linseed meal. Most of the grain mixtures recommended contain from one-sixth to one-eighth of oil meal, and in the proportion in which these mixtures are generally fed with milk and hay, the rations contain considerably more protein and have narrower nutritive ratios than whole milk, viz., on the average, 1:2.5 or 1:3. In view of the difference between this ratio and that of whole milk, and because of the important bearing of the question on general feeding practices

on the dairy farm, it is of interest to determine whether it is desirable to limit the selection of feeds for calves to farm grains and mill feeds. The experiment reported in the following pages was, therefore, conducted as a preliminary study of calf-feeding problems, with special reference to California conditions.

The experiment was begun November 19, 1914, and continued for ten weeks. Sixteen calves, most of them about a month old at the beginning of the experiment, were separated into two lots that were as uniform as possible as regards previous history, age, weight and breeding. There were seven grade Holstein calves, sired by pure-bred Holstein bulls in each lot, and in addition Lot I contained a pure-bred Holstein bull calf, and Lot II a pure-bred Guernsey bull calf. The calves in Lot I were fed a grain mixture consisting of two parts each of ground barley, ground oats and wheat middlings, and one part of linseed meal, all by weight. Those of Lot II received the same mixture except that no linseed meal was given. The amount of grain fed was gradually increased from one-fourth or one-half pound at the beginning of the trial, to one to two pounds at the close, according to the size and appetite of the individual calf. All calves had been changed to skim milk before the experiment commenced, and this was fed warm from the separator twice a day, in such amounts as they seemed able to consume without scouring, ten to fourteen pounds being fed daily to each calf. In addition, alfalfa hay was supplied twice daily, as much as they would clean up; clean fresh drinking water was likewise given twice a day. All the feed eaten by the individual calves was weighed carefully, except the hay which was weighed out for each lot; this was placed in racks in the two calf pens and the amount eaten was apportioned equally between the calves in each lot. There was naturally more or less hay wasted by this method of feeding, and the amounts credited to the different calves are, therefore, somewhat in excess of what they actually ate, but it is believed that no serious error was introduced in the experimental results by the method of feeding adopted.

The calves in each lot were kept in separate pens, and were fastened with halter straps at feeding time. They were fed skim milk in clean, steamed pails, and the grain mixture was fed in the mangers directly after the skim milk. The calves were left loose in the pens the rest of the time, and were let out into a separate corral for a few hours each day, except in rainy weather. They were weighed for three consecutive days at the beginning and at the close of the experiment, and regularly once a week during its progress, so that the changes in body weight for each animal were followed closely from week to week.

The trial proceeded without important incidents except that one of the calves in Lot II (Inez, a grade Holstein) often did not take all her milk or grain feed; the gains made by her from week to week varied considerably and were on the whole rather unsatisfactory, viz., 0.57 pounds per day on the average for the whole trial, against 0.93 to 1.53 pounds for the other calves in the same Lot, and 0.86 to 1.47 pounds for the calves in Lot II. The reason why this calf did not do better, is doubtless to be sought in her constitutional weakness, aggravated by

Fig. 3.—Calves in Lot I, Trials I and II.

Fig. 4.—Calves in Lot II, Trials I and II.

the fact that she was changed to skim milk at a very early age (when less than two weeks old) and perhaps too rapidly, in order to include her in the trial. Under these conditions it seems fair to omit the results for this calf from the summary of the feed eaten and gains made by this lot. Average figures including data for her are, however, also given in the table in order to make the results secured for all the calves available to those interested. The following summary table shows the main results obtained in the trial:

SUMMARY OF RESULTS OF TRIAL I

	Lot I Linseed meal	Lot II No linseed meal Av. for 7 calves	Lot II No linseed meal Including Inez
Average age at beginning, days	41	36	33
Weight at beginning, pounds	124.1	124.4	123.1
Average gain per head, pounds	1.13	1.21	1.13
Daily rations fed per head, pounds:			
Grain	.9	.9	.9
Skim milk	11.6	11.8	11.6
Alfalfa hay	2.6	2.5	2.6
Total feed units in rations	4.1	4.1	4.1
Dry matter in rations, pounds	4.06	3.98	4.05
Digestible protein	.74	.71	.71
Digestible carbohydrates and fat	2.17	2.16	2.19
Nutritive ratio, 1:	2.9	3.0	3.1
Dry matter per pound of gain, pounds	3.59	3.29	3.58
Dry matter per pound gained, pounds	3.59	3.29	3.58
Cost of ration, cents	5.7	5.6	5.6
Feed cost per pound of gain, cents	5.0	5.0	4.6

It will be seen that the average rations fed the calves on this trial consisted of nine-tenths of a pound of grain, 11.7 pounds of milk and about 2.5 pounds of alfalfa hay. The rations were gradually increased as the calves grew older. At the beginning of the trial these received from one-half to three-fourths of a pound of the grain mixture per head daily, and 10 to 14 pounds of skim milk. The amounts of hay eaten by the individual calves could not, as already stated, be determined under the conditions of this trial. At the end of the trial the calves each received from 1 to 2 pounds of grain and from 10 to 14 pounds of skim milk daily, the average amount of hay eaten being 3.3 pounds, against 1.5 pounds at the beginning of the trial.

The variations in the average weekly gains in body weight by the calves in the two lots may be seen from the accompanying diagram. It will be noted from the curves for both lots that the gains in weight varied considerably from week to week, and that the calves in Lot II of this trial, on the average, made no gain whatever one week. This also happened once during the second trial; in this case likewise in the case of the lot receiving grain without linseed meal.

The results obtained in this trial indicate that no advantage was gained by including linseed meal in the grain mixture of the calves, in so far as the increase in body weight or the cost per pound of gain is concerned. There was a decrease of nearly 10 per cent in the

amount of dry matter eaten per pound of gain made by Lot II, as compared with Lot I, and it was noticeable that the calves in the latter lot always ate their grain ration with relish, while the appetites of several calves in Lot II were at times somewhat uncertain. The calves in this lot did not, on the whole, appear to relish their grain as did the calves receiving the mixture containing linseed meal. These also appeared to have a somewhat smoother and more pliable skin, and a more thrifty appearance in general, but the difference was not marked. The calves in Lot II were in excellent condition with the exception of Inez, and made satisfactory gains throughout the trial. Whatever advantage was derived from including linseed meal in the grain mixture was, therefore, slight and the results do not lead to definite conclusions as to the desirability of making linseed meal a component part of the grain mixture for skim milk calves.

TRIAL II. Linseed Meal With Milo and Barley for Skim-Milk Calves

In view of the results obtained in the preceding trial, it was decided to conduct another trial along the same line with a different calf feed mixture, viz, ground barley and ground milo, with or without linseed meal. These feeds were mixed in the proportion of 3:2:1 by weight, for milo, barley and linseed meal (Lot I), and 3:1 for milo and barley (Lot II). Skim milk and alfalfa hay were fed in similar amounts and manner as in the first trial, and the conditions under which this and subsequent trials were conducted were in general similar, so that further details describing these trials will not be necessary. The trial was conducted with the same sixteen calves as in the first trial, and in addition, a third lot of 8 younger calves, one to two months old at the beginning of the trial was included, and was fed the same grain mixture as Lot II, receiving no linseed meal. Of the calves in Lot III, 5 were pure-bred Holstein males, 1 pure-bred Holstein female, 1 female Guernsey grade, and 1 cross-bred male with considerable Angus blood. The trial was commenced February 4th and continued for 77 days, until April 22nd; Lot III was continued on the same system of feeding for another 49 days, until June 4th. Of the calves in Lot II, Inez again showed considerable variation, in appetite and the way she responded to the feeding. She gained on the average .97 pound per day during the trial, against gains of 1.72 pounds to 2.37 pounds for the other calves in the lot, and of 1.84 pounds of 2.32 pounds for the calves in Lot I. It is believed, therefore, that comparison between the two lots, and a study of the effects of

the two systems of feeding used, should be made after excluding her as before. Data are, however, also given for the entire lot of calves including Inez.

The feeding and care of the calves included in this trial were

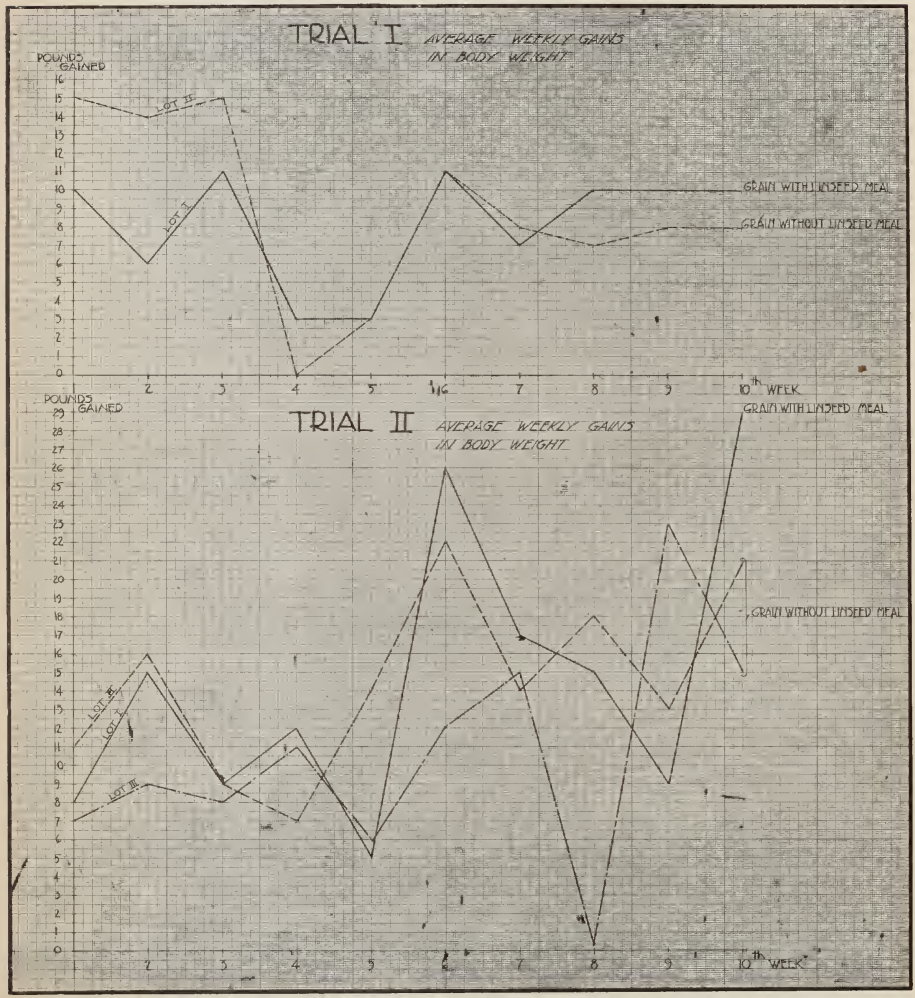

Fig. 5.—Chart showing weekly gains by calves in Trials I and II, fed grain mixtures with or without linseed meal.

entrusted to two senior students in the College of Agriculture, Messrs. W. B. Hubbard and Carl J. Williams, who did this work in a conscientious and very efficient manner, as a part of their thesis requirements for a baccalaureate degree. The following table gives the main facts of the trial.

SUMMARY OF RESULTS OF TRIAL II

	Lot I (Linseed meal)	Lot II (No linseed meal) Without Inez	Lot II (No linseed meal) With Inez	Lot III (No linseed meal)
Average age at beginning, days	101	95	92	42
Weight at beginning, pounds	200.6	207.3	200.0	126.5
Average gain per day, pounds	2.0	2.03	1.90	1.45
Daily rations fed per head, pounds:				
Grain	2.0	2.0	1.9	.8
Skim milk	11.6	11.4	11.3	11.8
Alfalfa hay	5.5	5.5	5.5	2.8
Total feed units in rations	6.7	6.7	6.6	4.1
Dry matter in rations, pounds	7.45	7.41	7.32	4.15
Digestible protein, pounds	1.13	1.04	1.02	.72
Digestible carbohydrates and fat, pounds	3.93	3.98	3.90	2.21
Nutritive ratio, 1:	3.5	3.8	3.8	3.1
Dry matter per pound of gain, pounds	3.73	3.65	3.85	2.86
Cost of rations, cents	8.8	8.6	8.5	5.6
Feed cost per pound of gain, cents	4.4	4.2	4.5	3.8

The results of this trial point in the same direction as those of the preceding one. There is no appreciable difference in the average data for Lots I and II, as regards the daily gains made by the calves or the amounts of feed eaten; slightly more dry matter was consumed per pound of gain by Lot I than by Lot II, and the cost of the rations fed as well as the gains made were somewhat higher for Lot I. It is, however, safe to conclude from the results obtained in both trials, that linseed meal is not a necessary component of rations for skim-milk calves and does not produce better gains than similar grain rations with linseed meal left out. It does tend, however, to make a grain mixture more palatable to the calves and improves the appearance and handling quality of the calves to some extent. Slightly larger gains were made by the lots in both trials that received a grain mixture without linseed meal, but the difference is too small to be of any importance in either case, being within the limits of experimental errors in trials of this kind.

RESIDUAL EFFECT OF RATIONS

In order to determine whether the feeding of linseed meal produced any residual effect, tending to make the calves stronger and thriftier, so that they would make better gains during the period following the trials than when no oil meal was fed, they were weighed once a month while on pasture after the trial was discontinued, for a period of 160 days. None of the calves received any extra feed during this time.

The average daily gains of the two lots during this period were as follows:

Lot 1 (linseed meal) 1.60 pounds,
Lot II (no linseed meal) 1.59 pounds.

Here again no appreciable difference was found in the gains made by the two lots; we may conclude, therefore, that whatever advantage may be derived from including linseed meal in the grain ration for dairy calves fed skim milk and alfalfa hay, will come from increasing somewhat the palatability of the feed to the calves and improving slightly the appearance of the latter, and not from any superior nutritive effect of such rations. It is not necessary, therefore, to make this usually high-priced feed a part of the grain ration for thrifty calves that have been successfully brought over to a skim-milk diet.

NUTRITIVE RATIOS OF RATIONS FED

The nutritive ratios of the rations in which linseed meal made up a part of the grain mixture for the calves, were somewhat narrower than those of the corresponding rations without linseed meal; the differences were not marked in any case (1:2.9–3.5, against 1:3.0–3.8), but since the nutritive ratios of the latter rations were always below 1:4, it is evident that no special advantage could be expected from a physiological point of view, from including linseed meal in the grain mixture of the calves. Skim milk and alfalfa hay are both high in protein (nutritive ratio, 1:1.6 and 1:3.8, respectively), and it is not likely, therefore, that sufficient amounts of carbonaceous grain feeds could be fed to render it advisable to include linseed meal in the grain mixture in order to bring the nutritive ratio of the rations down to below 1:4. The sole justification for including linseed meal in calf mixtures will, therefore, be found in the improvement in palatability and dietetic effect that this feed may bring about. Since the market price of linseed meal in this state is, as a general rule, 30 to 40 per cent higher than that of barley and other grain feeds, rations containing linseed meal are more expensive than those without it, and it is a question whether the small benefits that may be derived from including this feed are of sufficient importance to warrant its use, except in the case of less thrifty calves that may need extra care and attention.

TRIAL III. Barley, Shorts and Linseed Meal for Dairy Calves

The trial was conducted with five calves during the period May 27 to September 16, 1915, the object in view being to secure definite information as to the gains that may be secured by heavy feeding of skim-milk calves. The calves were about two months old at the beginning of the trial and had been changed from whole milk to skim milk shortly before the beginning of the trial; three were pure-bred Holsteins, one grade Holstein, and a Guernsey-Shorthorn grade, there being one male and four females in the lot.

Ground barley, wheat shorts, and linseed meal, in the proportions of 3:2:1 by weight, were fed in addition to alfalfa hay and skim milk. The daily gains made by the different calves during the 112 days of the trial ranged from 2.09 pounds to 2.71 pounds, the average being 2.48 pounds per head. This is a most satisfactory increase in body weight for young dairy calves. The main results obtained in the trial are shown in the following table:

SUMMARY OF RESULTS OF TRIAL III

Average age at beginning, days	69
Weight at beginning, pounds	172.8
Average gain per day, pounds	2.48
Daily rations fed per head, pounds:	
Grain	2.0
Skim milk	14.3
Alfalfa hay	7.3
Total feed units	7.7
Dry matter in ration, pounds	9.47
Digestible protein, pounds	1.38
Digestible carbohydrates and fat, pounds	4.93
Nutritive ratio	1:3.6
Dry matter per pound of gain, pounds	3.82
Cost of ration, cents	10.4
Feed cost per pound of gain, cents	4.2

While the cost of the ration was relatively high, owing to the large amounts of feed eaten, the cost per pound of gain in body weight was lower than for most of the lots fed in the preceding trials. The results of the trial suggest that skim-milk calves can readily be brought up to a weight of over 450 pounds at an age of six months on a ration of skim milk, alfalfa hay, and a suitable grain mixture, at a feed cost of but little over four cents per pound of gain in body weight, from the time they are put on skim milk.

Many dairy farmers consider it the best practice to feed their

young stock heavily as in this experiment, and thus raise especially large and thrifty calves. There is considerable evidence showing that calves of good breeding fed in this way will develop into very satisfactory dairy cows, with a strong constitution and a capacity for large dairy production. Under this system of heavy feeding the dairy calves must be fed rations rather high in protein substances, like those given in this bulletin, which will produce a strong frame with a good development of body tissue without deposition of excessive fat. We have seen that with skim milk and alfalfa hay there is no danger that the rations fed will not contain an abundance of protein.

TRIAL IV. Carob Pods vs. Barley for Skim-Milk Calves

At the request of Mr. C. W. Beers, Horticultural Commissioner of Santa Barbara County, a feeding experiment with carob pods for calves was conducted during the past fall and winter. These pods are obtained from the carob tree (*Ceratonia Siliqua*), an evergreen tree growing in pastures and waste places in the southern part of the state. It is commonly grown in the coastal regions of southern Europe and on many islands in the Mediterranean Sea, and the pods are highly prized in these countries as a feed for horses, cattle, sheep and swine. They are also used as a human food, somewhat like sugar cane in the south, or for cooking, ground with cereal grains. Their value for feeding purposes depends on the high content of sugar and starch in the pods. The high sugar content in the pods, which in some varieties and seasons reaches 40 to 50 per cent of sucrose and reducing sugars, renders them especially palatable to young stock. According to Pott,[1] "the crushed carob pods are frequently used in England for fattening sheep, and for ewes with lambs, also in connection with other concentrates for fattening steers. It is used in France as a feed for milch cows and young stock, and in southern Italy and other countries as a concentrate for horses and for growing pigs. British horses are at times fed as much as 3 kilos (6.6 pounds) per head, of carobs daily, either cooked and mixed with cut straw, or raw. Fattening steers are also fed preferably cooked carobs towards the end of the fattening period. For horses it is not even necessary to crush the pods. In southern Italy nobody would think of doing it, although the strong pony-like horses do not receive any other concentrates, and are fed only hay or green feed in addition."[2]

[1] Futtermittellehre, Vol. II, part I, p. 453 to 455.

[2] For a discussion of the Carob and its adaptability to conditions in this State, see address by C. W. Beers before the 44th Fruit Growers' Convention at Davis, California, June 1914, in California Farm and Home, July 19, 1914. Chemical analysis in Cal. Exp. Sta., Rept. 1903–4. p. 49.

The carob tree grows well in this state especially in the southern coastal counties, and may be planted in stony and other waste places. It is reported to yield 300 to 500 pounds of pods per tree when full grown. In view of the favorable reports on the pods from foreign countries, it appeared desirable to secure accurate information as to their value for stock feeding under California conditions. It was thought that the pods might be found especially useful as a constitutent of calf meals and a trial was, therefore, planned with a view to obtaining definite data on this point, especially as to their value when mixed with ground milo in comparison with ground barley and milo, both of which are standard grain crops in this state and may be raised on most of our ranches.

Fourteen calves separated into two lots of eight and six each, were included in the trial; seven of these were from one to two months old, and seven only about a week old at the beginning of the trial. The former were pure-bred Jerseys, Guernseys, Ayrshire and Holstein calves of our own breeding, three males and four females, while the latter were high-grade Holstein female calves bought for this trial. The older calves were changed gradually from whole milk to skim milk during the second and third week of the trial, and the young ones during the fifth and sixth week. The trial was continued for 13 weeks, October 21, 1915, to January 20, 1916. The two lots were fed as follows:

Lot I, Carob pods and ground milo, 1:1 by weight,
Lot II, Ground barley and ground milo, fed in the same proportion.

The calves received from less than ½ to three pounds of the grain mixture per head daily, according to age and capacity; and in addition 14 to 25 pounds of milk and alfalfa hay *ad libitum* (2.3 to 6.1 pounds per head daily).

Some difficulty was experienced at first in preparing the pods for feeding; efforts to grind them in an ordinary feed mill were unsuccessful, as the gummy substances in the pods soon clogged the plates, whether the pods were run through alone or mixed with milo. It was found, however, that the ordinary machinery used in rolling barley or oats would crush the pods so that they could be readily eaten by stock. The pods were flattened and broken into pieces of varying sizes by this method of preparation, and fair proportions of the hard beans were also crushed or flattened in the process of rolling. The pods thus prepared were mixed in equal proportions by weight with ground

milo and fed to Lot I. The calves relished the pods greatly, and as a rule, ate them before the milo. The main results of the trial are summarized below:

SUMMARY OF RESULTS OF TRIAL IV

	Lot I Carob and Milo	Lot II Barley and Milo
Average age at beginning, days	28	30
Average weight per head, pounds	131.8	116.7
Average gains in body weight per day, pounds	1.81	1.70
Average ranges in daily gains, pounds	1.67–2.03	1.32–2.09
Daily rations fed per head, pounds:		
Grain	.8	.7
Whole milk	5.0	4.5
Skim milk	14.2	13.3
Alfalfa hay	2.6	2.6
Average rations contained, pounds:		
Dry matter	4.86	4.62
Digestible protein	.92	.89
Digestible carbohydrate and fat	2.93	2.75
Nutritive ratio, 1:	3.2	3.1
Total feed units in ration	6.2	5.7
Dry matter per pound of gain, pounds	2.69	2.72
Cost of rations, cents	16.1	14.8
Feed cost per pound of gain, cents	8.9	8.7

While the composition of the average rations fed to the two lots varied somewhat, it is evident from the results obtained that the carob-milo mixture had at least a similar feeding value to the barley-milo mixture. The lot fed the former mixture gained an average of 1.81 pounds per head daily during the trial, against 1.70 pounds for the the barley-milo mixture. The average gain in the body weight for the older calves (50 days old at the beginning of the trial) was for Lot I, 1.90 pounds, and for Lot II, 1.74 pounds; for the younger calves (7 days old at the beginning of the trial), Lot I, 1.72 pounds, Lot II, 1.65 pounds. The cost of the rations fed and the average feed cost per pound of gain were higher than in the preceding trials, for the reason that considerable whole milk was fed during the first half of the feeding period, the calves included on the trial being younger than in the earlier ones. If only the second half of the trial be considered, when the ration fed consisted of grain, hay and skim milk, the results would come as follows:

	Lot I	Lot II
Average age at beginning, days	64	66
Average body weight at beginning, pounds	191.2	169.8
Grain per head, pounds	1.87	1.79
Rations fed, pounds:		
Grain	1.1	.9
Skim milk	19.6	18.4
Hay	3.8	3.8
Cost of rations, cents	8.5	7.9
Feed cost per pound of gain, cents	4.5	4.4

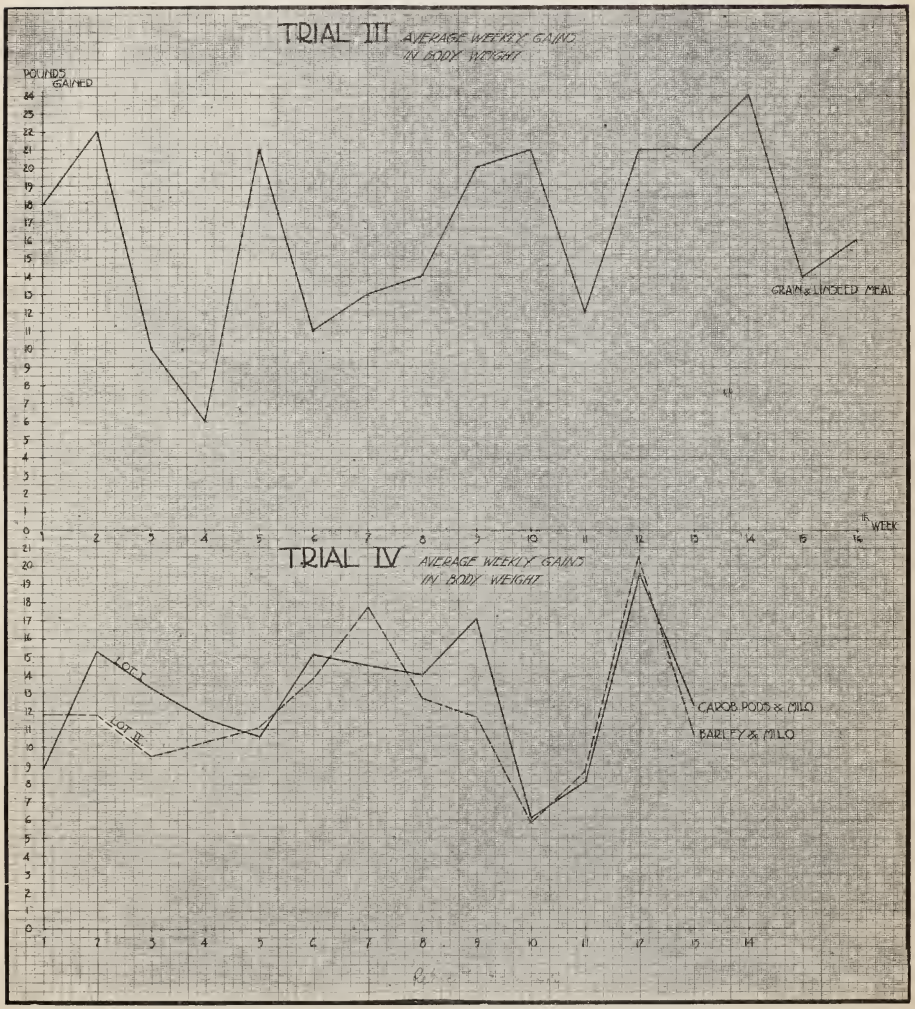

Fig. 6.—Chart showing weekly gains by calves in Trials III and IV, fed grain and linseed meal, and carob pods and milo vs. barley and milo, respectively.

Whether the data for the entire feeding period are considered or only those for the latter half, when no whole milk was fed, the same conclusion may be drawn from the results, viz., that the nutritive effect of the carob-milo mixture was fully equal to that of the barley-milo mixture, or the carob pods may be considered of similar value to barley, at least as a feed for calves.

There is no marked difference in the chemical composition of these two feeds, as will be noted from the analysis given on pp. 23–24 of this bulletin. The digestibility of carob pods has been determined in four trials (with two different samples); the average digestion coefficients obtained show a relatively low digestibility of the protein substances (34 per cent), and a medium digestibility of the fat (56 per cent). Eighty-six per cent of the nitrogen free-extract (sugar, starch, etc.) were, however, found to be digestible, and since these substances make up nearly three-fourths of the weight of the pods, the nutritive effect of these will depend almost wholly on their contents of digestible carbohydrates. The average digestible components in the carob pods are: protein 2.4 per cent, carbohydrates and fat 66.5. per cent (nutritive ratio, 1:27.7; see page 24); while the corresponding figures for the barley fed in the trial were 8 per cent and 68.9 per cent (nutritive ratio, 1:8.6 per cent). It would appear from the results of this trial that the digestibility and the nutritive effect of the carob pods are somewhat higher than are indicated by the available average data for this crop.

The results of the trial described in the preceding pages indicate that carob pods make a very valuable component of a grain mixture for skim-milk calves, and to this extent at least they corroborate European feeding experience with this feed. If the carob tree will thrive in certain sections of the state, like the central and southern coastal counties, as appears to be the case, then farmers in this region may well plant the tree on non-arable land, in pastures, hill-sides and stony places, etc., and thus in time be able to secure a regular supply of a highly palatable and valuable feed for their stock, without further effort and expense than the harvesting of the fruit.

TRIAL V. A Comparison of Dried Beet Pulp and Cocoanut Meal for Dairy Calves

Both dried beet pulp and cocoanut meal are common dairy feeds in this state. They are generally fed to dairy cows and fattening steers, and in the case of cocoanut meal, at times to pigs and horses; but little is known in regard to their value for feeding dairy calves,

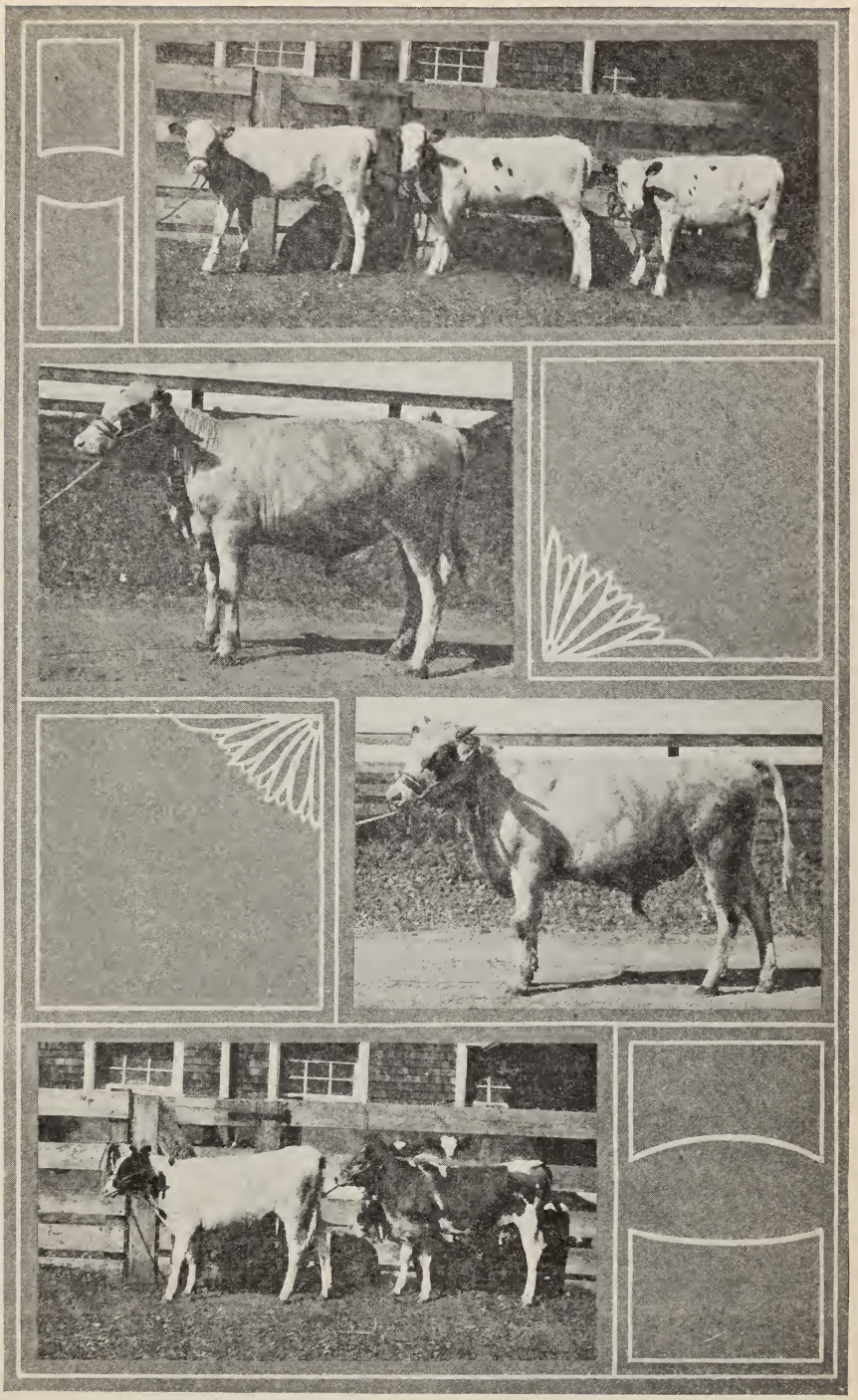

Fig. 7.—Calves in Trial V, Lot I, at the close of experiment.

and an experiment intended to furnish information on this point was accordingly planned. The fourteen calves in the preceding trial were continued on this one, a week's intermediate feeding being introduced in order to accustom them to the ration to be fed in this trial. The grouping of the calves into two lots was changed from that of the preceding trial so as to guard against any residual effect of the previous system of feeding on the results of the trial. Lot I was fed two parts rolled barley and one part dried beet pulp, while Lot II received two parts rolled barley and one part cocoanut meal, in both cases by weight. All calves were fed separator skim milk and alfalfa hay, in addition to the grain mixtures, until February 24 to March 9, when six of the older calves, three in each lot, were gradually weaned, and these received only dry feed after March 9.

The calves ranged in age from 93 to 171 days at the beginning of the trial, the average age of those in Lot I being 122 days and those in Lot II 123 days. This trial was arranged for as thesis work for two senior agricultural students, Messrs. C. V. Castle and W. F. Elder, who had charge of the feeding and care of the calves during the experimental period. Much credit is due to these students for the careful and conscientious manner in which their work was done. The most important data obtained in connection with the trial are shown in the following statement.

SUMMARY OF RESULTS OF TRIAL V

	Lot I Beet pulp and barley	Lot II Cocoanut meal and barley
Average age at beginning, days	122	123
Average weight per head, pounds	287.1	280.9
Average gains in body weight per day, pounds	2.08	1.84
Average ranges in gain, pounds	1.50–2.41	1.54–2.00
Daily rations fed per head, pounds:		
Grain	2.3	2.2
Skim milk	14.4	13.7
Alfalfa hay*	10.1	9.7
Average ration contained, pounds:		
Dry matter	11.77	11.28
Digestible protein	1.55	1.58
Digestible carbohydrates and fat	6.39	6.10
Nutritive ratio, 1:	4.1	3.9
Total feed units in ration	9.7	9.3
Dry matter per pound of gain, pounds	5.66	6.13
Cost of ration, cents	12.1	11.6
Feed cost per pound of gain	5.8	6.3

* No allowance made for waste in feeding hay.

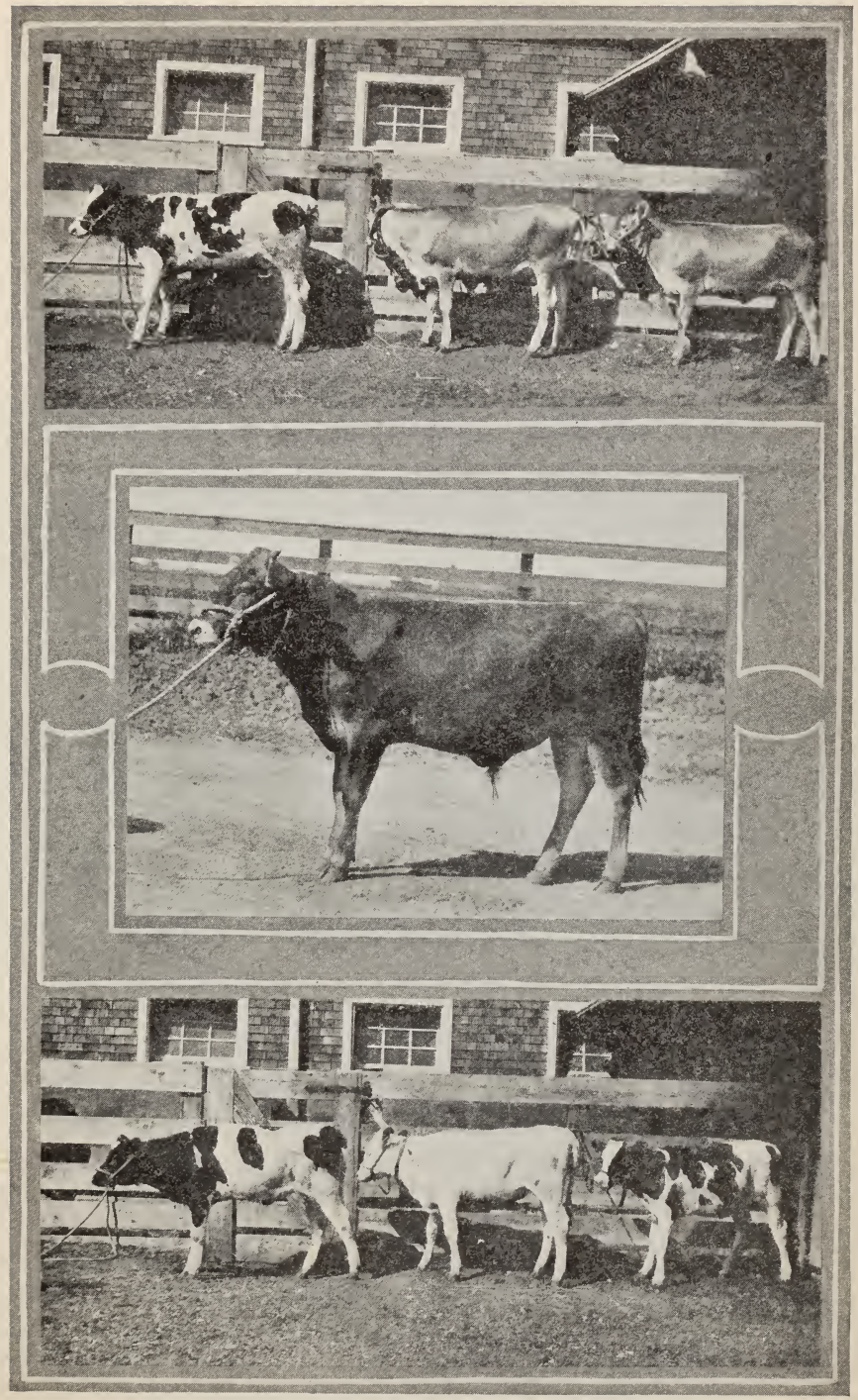

Fig 8.—Calves in Trial V, Lot II, at close of experiment.

In this, as in the other trials reported in the preceding pages, no allowance was made for waste in feeding the hay in racks in the calf pens. This waste was apparently of greater importance in the case of the older calves on this trial than in the earlier ones. Under the conditions stated the amounts of hay given and the composition of the rations fed are mainly of value for comparison of the results obtained with the two lots; the figures given cannot be taken to represent the exact amounts of hay or of digestible components in the rations actually eaten by the calves.

The calves included in the trial gained, on the average, as follows in body weight: Lot I (dried beet pulp and barley) 2.08 pounds per

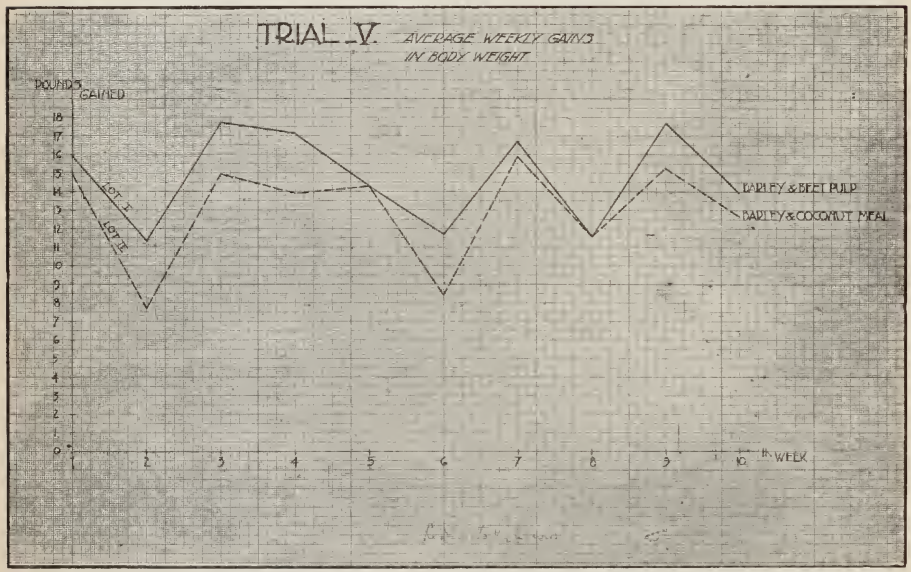

Fig. 9.—Chart showing weekly gains by calves in Trial V, fed beet pulp and barley vs. cocoanut meal and barley.

head daily and Lot II (cocoanut meal and barley) 1.84 pounds. Only one of the calves in the former lot gained less than two pounds daily, on the average for the 70 days of the trial, while six of those in Lot II gained less than two pounds. The average amounts of feed eaten by the calves in the two lots did not differ materially. It is evident, therefore, that the nutritive effect of the beet pulp-barley mixture fed with skim milk and alfalfa hay was somewhat (viz., about 10 per cent) higher than that of the cocoanut meal fed in similar amounts and combinations. The results of the trial indicate that both these concentrates fed, as stated, to dairy calves, will produce satisfactory gains in body weight. Both rations proved palatable to the calves.

The cocoanut meal had a tendency to cause scouring in the case of some of the calves; it is also, as a general rule, somewhat higher in price in this state than dried beet pulp; as it moreover did not produce as good gains as the latter feed, there is no reason for feeding it to skim milk calves in preference to dried beet pulp or other equally satisfactory grain feeds that can be obtained at a similar or lower cost.

As beet pulp and cocoanut meal are ordinarily two of the cheapest dairy feeds available to our farmers, and as both produce very satisfactory results in this trial, either may, however, be recommended for feeding dairy calves whenever it seems desirable to give variety to the grain mixture fed. The grain feed used in this trial (two parts of barley to one of either of the concentrates mentioned) may be fed when barley is relatively cheaper than the two other feeds; otherwise a proportion of equal weights of barley and beet pulp, or better still, a mixture of barley, beet pulp and cocoanut meal in the proportions 2:1:1 may be fed. This will make an excellent grain ration, especially for older skim-milk calves, it being both palatable and cheap at ordinary feed prices in this state.

GENERAL DISCUSSION OF FEEDING DAIRY CALVES

The results of the five feeding trials with dairy calves reported in the preceding pages show that vigorous, thrifty calves, of very satisfactory body weights, can be readily raised on separator skim milk, grain feeds and hay. It is, as a rule, only necessary to feed whole milk during the first two weeks of the calf's life, and the expense of raising the calf may thus be kept down to a minimum. The young calf should receive 10 to 20 pounds of milk daily, according to size and thriftiness, and a small amount of a grain mixture is fed from the time it is brought over onto skim milk, viz., less than ¼ pound daily for calves only a couple of weeks old, to 2 or 3 pounds toward weaning time at four to five months old. The grain mixture should consist of starchy concentrates or of such as are low in protein, like rolled barley, oats, wheat bran or middlings, milo, kafir, Indian corn, dried beet pulp, cocoanut meal, crushed Carob pods, etc.; in the case of more or less delicate calves that do not eat their feed readily, a small proportion of linseed meal may be included in the grain mixture. Indian corn, oats and middlings are ordinarily too expensive to be used for feeding calves under our conditions. A fine quality of clean bright hay should be placed before the calves

twice daily, in addition to skim milk and grain, in such amounts as they are likely to clean up.

Only heifer calves from the best cows in the herd should be raised to be added to the herd, since calves from other cows will not be likely to develop into profitable dairy cows. Calves not raised for the dairy herd may be fed for veal and disposed of at about two months of age or later. Whole milk can only be fed with profit during all or most of this time when a special price can be obtained

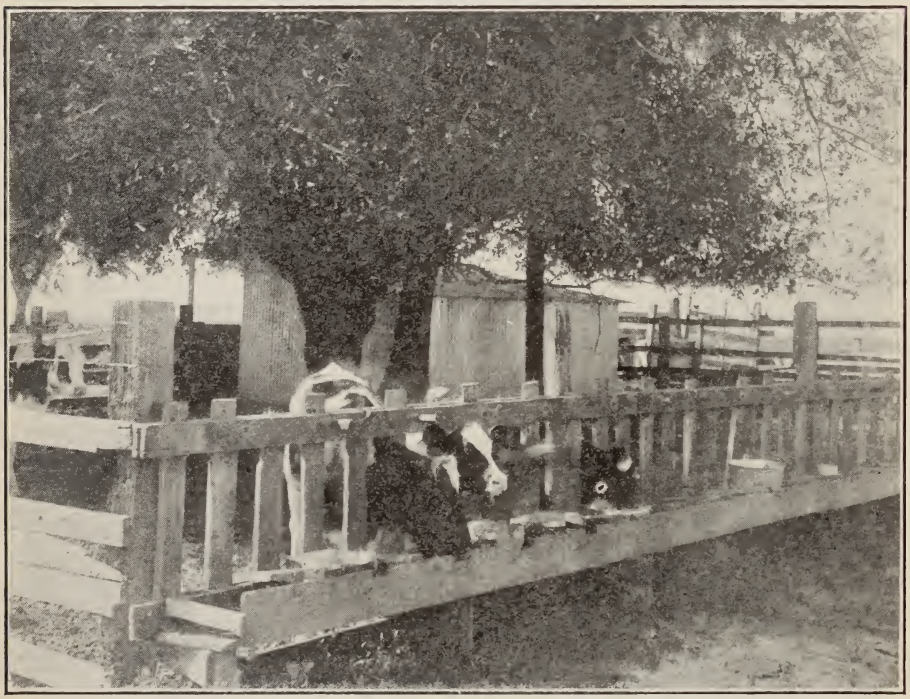

Fig. 10.—Home-made calf stanchions.

for a superior article. Such markets are rarely found outside of the large cities, and even there the demand for choice veal is limited, although increasing. Most calves that are to be vealed must, therefore, be fed skim milk after the first couple of weeks; some farmers allow veal calves to run with the cows, generally placing two calves to a nurse cow, or continue the feeding of whole milk along with skim milk until the calves are sold, but this method increases considerably the cost of the ration. It is not necessary to feed whole milk for making an excellent quality of veal; and this can be produced on skim milk supplemented with suitable grain feed and hay, as above

suggested. The method of feeding in this case does not differ from that of raising skim-milk calves for the dairy, except that the calves are fed all the grain they will eat with relish, so at to insure rapid gains in weight. Good veal calves weighing 200 pounds or more may be sold at say two months of age, at a feed cost below $8 a head, figured at current market prices. The production of veal calves under the conditions stated, should form a profitable sideline for the dairy farmer, and calls for but little extra effort beyond providing clean sanitary quarters for the calves and feeding them plenty of wholesome nutritious feeds. Cleanliness and regularity in feeding are most important factors in successful calf raising.

If it is desired to feed the calves for a longer period than two months, good and economical returns may be received for the feed eaten, by continuing the system of feeding outlined. If the calves are dropped in the fall or winter, they may be put on pasture in the spring, and cheap gains made by feeding a few pounds of grain daily per head in addition, so as to keep them in a growing thrifty condition. It will be advisable to dispose of them before they are a year old, however, when they should weigh 600 pounds or better. So-called baby beef, a trade term for 15 to 18 months old steers, weighing 1000 to 1200 pounds, can only be raised from young beef-bred stock of a blocky type and inbred capacity for a large feed consumption and a rapid growth.

One of the common causes of failure in raising calves, is that of over-feeding, which usually results in scouring. When scouring occurs, the amount of milk fed should be immediately reduced, or in severe cases no milk is given until the trouble ceases. If no improvement follows, special means must be taken to stop the scouring. There are a number of remedies for this trouble that may usually be applied with satisfactory results. One of the simplest is castor oil, two tablespoonfuls being given with the milk or alone, once a day. Another remedy is a weak solution of formaldehyde. A stock solution is made up on one-half ounce of commercial formaldehyde added to one pint of water, and a teaspoonful of this solution is given in the milk per pint of milk. Blood meal will also often prove effective, being stirred into the milk in the proportion of a teaspoonful per feed; this is also a good tonic for weak young calves. The so-called Soluble Blood Meal or Blood Flour is preferably used for this purpose.

When skim milk cannot be obtained, it will be necessary to feed whole milk until the calves are sufficiently strong and thrifty to do well on a gruel of ground grain and mill feeds, at about three or four

weeks old. It is a difficult undertaking to raise very young calves successfully without milk and calls for constant care and watchfulness on the part of the feeder. Commercial calf feeds will give satisfactory results in some cases, but are relatively expensive. The following home-made mixture for young calves may be recommended under the conditions prevailing in our state: rolled or ground barley, oats, wheat middlings, and linseed meal or flaxseed meal, two parts of the first three feeds and one part of linseed meal, or of ground flaxseed, if this can be obtained at a reasonable price, say within a few dollars of the price of linseed meal per ton.

As suggested in the introduction to this bulletin, progress in dairying depends to a large extent on farmers raising the heifer calves from all the good cows in their herds. Only in this way can they take advantage of the improvement in the production of the herd which they have been able to reach, and maintain a high production in their herd. The purchase of mature pure-bred bulls or of heavy-producing cows is not possible for most dairy farmers, although no farmer can expect to make a success of dairying unless he places at the head of his herd the best pure-bred dairy bull that he can secure. It is a trite but true saying among breeders, that the bull is half the herd; he transmits to his offspring the capacity for a large dairy production that has been bred into him for many generations back, and is, therefore, likely to be worth all that he costs, and more; but cows of good or exceptional productive capacities are rarely for sale, except perhaps at fancy prices. Each farmer is, therefore, as a rule dependent on his own supply of calves for maintaining or increasing the production of his herd. Calves not intended to be added to the herd should be raised for veal. The data presented in this bulletin as to methods and results obtained in feeding various common feeds available in this state to dairy calves have shown how the latter can be raised successfully and profitably, either for the dairy herd or for veal. These discussions should prove of assistance to farmers in their efforts toward improving the production and the returns secured from the dairy herd.

STATION PUBLICATIONS AVAILABLE FOR DISTRIBUTION

REPORTS

1897. Resistant Vines, their Selection, Adaptation, and Grafting. Appendix to Viticultural Report for 1896.
1902. Report of the Agricultural Experiment Station for 1898–1901.
1903. Report of the Agricultural Experiment Station for 1901–03.
1904. Twenty-second Report of the Agricultural Experiment Station for 1903–04.
1914. Report of the College of Agriculture and the Agricultural Experiment Station, July, 1913–June, 1914.
1915. Report of the College of Agriculture and the Agricultural Experiment Station, July 1914–June, 1915.

BULLETINS

No.
168. Observations on Some Vine Diseases in Sonoma County.
169. Tolerance of the Sugar Beet for Alkali.
178. Mosquito Control.
184. Report of the Plant Pathologist to July 1, 1906.
185. Report of Progress in Cereal Investigations.
195. The California Grape Root-worm.
207. The Control of the Argentine Ant.
208. The Late Blight of Celery.
212. California White Wheats.
213. The Principles of Wine-making.
216. A Progress Report Upon Soil and Climatic Factors Influencing the Composition of Wheat.
225. Tolerance of Eucalyptus for Alkali.
227. Grape Vinegar.
230. Enological Investigations.
234. Red Spiders and Mites of Citrus Trees.
241. Vine Pruning in California, Part I.
242. Humus in California Soils.
246. Vine Pruning in California, Part II.
248. The Economic Value of Pacific Coast Kelps.
249. Stock-Poisoning Plants of California.
250. The Loquat.
251. Utilization of the Nitrogen and Organic Matter in Septic and Imhoff Tank Sludges.
252. Deterioration of Lumber.
253. Irrigation and Soil Conditions in the Sierra Nevada Foothills, California.
254. The Avocado in California.
255. The Citricola Scale.
256. Value of Barley for Cows Fed Alfalfa.
257. New Dosage Tables.
261. Melaxuma of the Walnut, "Juglans regia."
262. Citrus Diseases of Florida and Cuba Compared with Those of California.
263. Size Grade for Ripe Olives.
265. Cottony Rot of Lemons in California.
266. A Spotting of Citrus Fruits Due to the Action of Oil Liberated from the Rind.
267. Experiments with Stocks for Citrus.
268. Growing and Grafting Olive Seedlings.
269. Phenolic Insecticides and Fungicides.
270. A Comparison of Annual Cropping, Biennial Cropping, and Green Manures on the Yield of Wheat.
271. Feeding Dairy Calves in California.

CIRCULARS

No.
65. The California Insecticide Law.
69. The Extermination of Morning-Glory.
70. Observations on the Status of Corn Growing in California.
76. Hot Room Callusing.
82. The Common Ground Squirrels of California.
106. Directions for Using Anti-Hog Cholera Serum.
107. Spraying Walnut Trees for Blight and Aphis Control.
108. Grape Juice.
109. Community or Local Extension Work by the High School Agricultural Department.
113. Correspondence Courses in Agriculture.
114. Increasing the Duty of Water.
115. Grafting Vinifera Vineyards.
117. The Selection and Cost of a Small Pumping Plant.
118. The County Farm Bureau.
121. Some Things the Prospective Settler Should Know.
124. Alfalfa Silage for Fattening Steers.
126. Spraying for the Grape Leaf Hopper.
127. House Fumigation.
128. Insecticide Formulas.
129. The Control of Citrus Insects.
130. Cabbage Growing in California.
131. Spraying for Control of Walnut Aphis.
132. When to Vaccinate against Hog Cholera.
133. County Farm Adviser.
134. Control of Raisin Insects.
135. Official Tests of Dairy Cows.
136. Melilotus Indica.
137. Wood Decay in Orchard Trees.
138. The Silo in California Agriculture.
139. The Generation of Hydrocyanic Acid Gas in Fumigation by Portable Machines.
140. The Practical Application of Improved Methods of Fermentation in California Wineries during 1913 and 1914.
141. Standard Insecticides and Fungicides versus Secret Preparations.
142. Practical and Inexpensive Poultry Appliances.
143. Control of Grasshoppers in Imperial Valley.
144. Oidium or Powdery Mildew of the Vine.
145. Suggestions to Poultrymen concerning Chicken Pox.
146. Jellies and Marmalades from Citrus Fruits.
147. Tomato Growing in California.
148. "Lungworms."
149. Lawn Making in California
150. Round Worms in Poultry.
151. Feeding and Management of Hogs.
152. Some Observations on the Bulk Handling of Grain in California.
153. Announcement of the California State Dairy Cow Competition, 1916–18.
154. Irrigation Practice in Growing Small Fruits in California.
155. Bovine Tuberculosis.